Multimodal Screening & Management System of Mental Wellbeing in Low Resource Settings

Research Proposal

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1. Executive Summary

The present research work proposes to study mental wellbeing under the scope of three issues around it, viz.-depression, anxiety, and alexithymia (inability to understand emotions of self and others); and using artificial intelligence-based multimodal approaches (suitable in low resource settings) for screening and management of mental wellbeing.

Mental health issues are becoming a serious concern both in rural and urban areas. However, in low resource settings (resource constraint areas e.g rural, semi-urban and even some parts in urban areas), access to mental healthcare is not readily available. According to the World Health Organization (WHO), almost 7.5% of the Indian population suffers from some sort of mental health disorder. Issues like depression, anxiety, insomnia, bi-polar disorder, paranoia and obsessive personality disorders are becoming more widespread. People are more vulnerable to developing mental health issues as their lifestyle patterns, food habits, stressed workplaces, decreased physical activity, and altered social fabric change. In a country like India, talking about mental illness is not a socioculturally accepted norm. This is the reason why these issues go undetected, unaddressed and untreated. It has severe repercussions on an individual's life, family, society and, eventually, for the country. A mentally unsound person cannot be productive at the workplace, cannot enjoy life, and has disturbed family & social relationships. Mental health and wellbeing is a topic of interdisciplinary interest. It is studied and researched across disciplines like psychology, psychiatry, cognitive science and sociology. Many advancements have appeared in the form of new theories, findings and technical developments.

This is the era of artificial intelligence based revolutions. Industry 4.0 is the buzzword around. Healthcare sector in general and mental healthcare in particular need an interdisciplinary approach and solutions to some long-standing problems. Proposed research is an interdisciplinary effort to make the screening and management of mental health easy, accessible and accurate for all people. On the technological front, it will follow a multimodal approach using computer vision, machine learning and physiological signal processing for the accurate diagnosis of mental afflictions. Further, the expertise and

experience of mental health practitioners will also be taken into account to design, develop and test the system. Eventually, it will all come together to form a strong framework in which all stakeholders concerned with mental illness and wellbeing can connect and benefit. The research will yield some patents, new technology development and publication of research papers.

Although the issue is equally prevalent in urban as well as rural areas. There are more mental health illness related myths to be busted in rural areas through technological intervention and creating awareness. Therefore, the proposed research is expected to be equally beneficial for the rural and urban Indian population. However, more emphasis would be given to designing and developing solutions that are acceptable and effective for implementation in the rural parts of the country. The proposed research work will try to explore the possibility of creating a platform to connect, voluntarily self-assess and seek help for mental health issues after proper research.

2. Introduction

The World Health Organization (WHO) defines mental health as "a state of well-being in which the individual recognizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and can contribute to his or her community" [1]. Further, it includes "*subjective well-being, perceived self-efficacy, autonomy, competence, intergenerational dependence, and self-actualization of one's intellectual and emotional potential, among others"*. Mental illness is perceived in contrast with mental health. On account of mental illness, a person cannot utilize his abilities for productivity, enjoyment & self-fulfillment, and fails to cope with the normal levels of stress in life. Mental illness is becoming a serious problem in India as well. According to the WHO, almost 7.5% of the Indian population suffers from mild to severe mental illnesses. WHO labels India as the most depressing country. Mental disorders and illnesses account for the largest part of the non-fatal disease burden in India. As per the statistics of mental illness in the year 2017, 197·3 million people were found to be suffering from mental disorders in different states of India [2]. Further, 45·7 million (42·4–49·8) had depressive disorders

and 44·9 million (41·2–48·9) were found to be suffering from anxiety disorders. Depressive disorders, anxiety disorders, idiopathic developmental intellectual disability (IDID), schizophrenia, bipolar disorder, conduct disorder, autism spectrum disorders, eating disorders, and attention-deficit hyperactivity disorder (ADHD) are the most common mental illnesses in India [1]-[4].

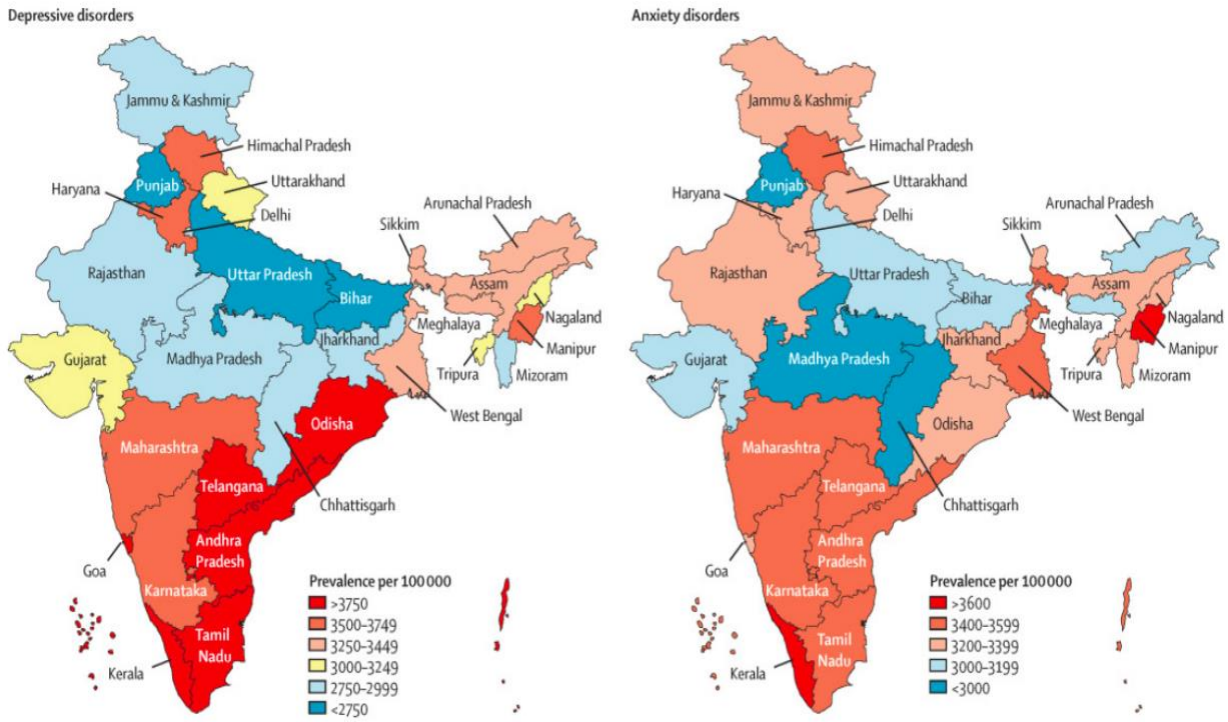

Figure 1 *: Prevalence of Mental Health Issue in India [2*]

In resource-deficient deficit developing countries like India, there are many challenges to implementing measures to tackle the issue of mental healthcare. Lack of funds is the prime detriment to implementing any such programme. There are not enough trained professionals to provide support. There is a need to create awareness and educate people about mental health issues.

In today's world, stress-related issues are common among working professionals, children, and the elderly. There are several studies available on it [4]-[6]. The industry association, ASSOCHAM, revealed in its 2015 survey that almost forty-two percent of working professionals in the Indian private sector suffer from depression and general

anxiety. There are several factors contributing to depression and mental health disorders. Stress and mental health problems can be identified by a person's behavior, like how she feels, eats, thinks, works, walks, etc., over a period of observation. Work pressure, working environment, people we interact with, daily routine work, food habits, time spent on social media, daily exercise time, monthly income and expenses, consuming alcohol and tobacco, and other factors are some of the major causes of stress in people. Stress can be detected through some conventional medical symptoms, such as headache, rapid heartbeats, a feeling of low energy, chest pain, frequent colds, infections, etc. Stress can also be seen in normal behavior while going about one's daily activities.

3. Literature Survey

India is a country full of diversity. When it comes to healthcare practices & systems, it is also full of variety. There exist different techniques, practices, and approaches as well as practitioners for healing mental illnesses [2] [3].

Psychologists practice different types of therapy, such as psychoanalysis, psychodynamic approaches, client centered approaches, cognitive behavioral therapy, and many more [3]. Similarly, psychiatrists, hypnotists and neuro-linguistic programmers have their own practices for mental health issues. Depression is attributed to being the leading cause behind suicides committed by the young population in the age group of 15 to 29 years. In India, one student commits suicide every hour.The availability of psychiatrists, trained psychologists, and nurses per one lac population is very low as compared to global standards. India completes only 68% of the checklist points on mental healthcare guidelines laid down by the WHO [1].

There are various social, physical, emotional and financial factors contributing to the onset or aggravation of mental disorders. Social experiences of an individual, such as unacceptability in society, fear, humiliation, and pressure, can lead a person to fall into the trap of mental illnesses. Some physiological factors, such as gender, age, genetic structure, pre-existing complications and family history, may contribute to the increased chances of developing mental disorders in a person. Personal trauma, tragedy, loss, and

bereavement can all lead to a person's mental health deterioration. According to a survey, one of the leading causes of depression and anxiety is financial liabilities and failure to fulfill them.

3.1 Mental Health in Rural India

There exists a wide gap and disparity in the accessibility of general healthcare services and mental healthcare is no exception to that matter. However, the government has taken various initiatives to tackle the issue of mental healthcare more inclusive and holistic. In this direction, new legislation has come into force through the Mental Health Act 2017. The new act aims to connect community-based mental health services and protect people suffering from such illnesses from discrimination or exploitation. There are many factors contributing to the increased number of mental illnesses in **rural** and low resource settings in India, such as the livelihood crisis, crop loss, social injustice, gender inequalities, substance use etc. [7]- [9]. Around 65% of the population lives in rural India. However, mental healthcare facilities are very rare in rural settings. The support of the local community health support system can play a vital role in providing mental healthcare services [10] and fighting against the stigma & prejudice attached to it [11].

3.2 Taboo and Stigma Attached with Mental Illnesses

Mental illness is the least talked about subject in India. There are many misconceptions and wrong beliefs attached to it. In low resource settings in India, the situation is horrible for those suffering from it. It is even worse for women as compared to men.

For most of these complications, people follow various malpractices, which are most of the time inhumane & torturous and performed by untrained quacks. Mental illnesses are believed to be the effect of some bogey spirit or supernatural causation [3].

It instills fear in those with whom it comes into contact or in society as a whole.People tend to distance themselves from the person suffering from it. There are various types of healers and healing practices in India. Biswal el al. [3] talks about them in detail.

3.3 Mental Illness Diagnosis and Management Approaches

For accurate prediction and estimation of mental illnesses, it is imperative to use multiple modalities of determination, such as a data driven approach, computer vision and EEG. A multicentric nationwide study conducted in India reveals the stigma and misconceptions attached to mental illnesses [4]. In the last few years, there have been some policy changes and government initiatives in a positive direction. The right to mental healthcare is one such move for the betterment of accessibility and services for the Indian people [5]. There are many approaches and tactics that can help cure mental illnesses. These include using social media, seeking assistance from peer support groups, awareness and anti-stigma campaigns, expert support, and technological interventions, among other things [6]- [10].

3.3.1 AI based Technological Interventions in Mental Healthcare

As far as the use of AI enabled technology is considered in mental health screening & management, there exist various approaches to it. Machine learning, computer vision, AI based psychometric analysis and physiological signal processing (such as electroencephalogram signals) have been used in the literature.

3.3.1.1 Use of Machine Learning in Mental Healthcare

Data is everywhere. The same is true in the field of mental health care.Machine learning models can learn from this data and can help with prediction, classification, association and clustering applications. Machine learning applications in the mental health domain fall under three categories, namely, supervised, unsupervised and reinforcement. Cho et al [16] present a review of various machine learning algorithms used to diagnose mental illnesses. Further, discussion of behavioral modeling for mental health can be found in the work of Srividya et al. [17].

The data driven techniques based on machine learning and deep learning, in psychiatry and mental healthcare, are making it more precise and accurate to form the basis of decision making [18] [19]. Furthermore, these techniques have been found effective in suicidal risk assessment in patients with various diseases such as schizophrenia and depression [20].

3.3.1.2 Use of Computer Vision in Mental Healthcare

Another important cue for mental diseases diagnosis is the visual data of patients. It may be in the form of images or videos. Computer vision based image or video content analysis finds applications in emotion identification, mapping and analysis. With the help of some advanced techniques, it may be useful in the mental healthcare domain. There are many interesting applications available in literature such as schizophrenia symptomatology [21][22], identification of behavioral markers for obsessive compulsive disorders [23] and facial expressions based emotion analysis [24][25].

3.3.1.3 Use of Internet of Things (IOT) & Physiological Signal Processing in Mental Healthcare

The Internet of things (IOT) and physiological signals can be used for emotion recognition in humans [26]-[32]. The most important physiological signal type for analyzing the emotional state of an individual is the electroencephalogram (EEG). Physiological changes take an important place in our emotional experiences. Emotion is a psychophysiological process in and of itself [27] [28]. It is produced in response to a stimulus by the limbic system activity and activates the somatosensory system [29]. EEG signal processing can be coupled with wavelet transformation [29], deep learning [30] and cloud data analytics [31][32] to diagnose schizophrenia [30], telemedicine in mental health [27], depression & other mental disorders [31].

4. Research Gaps

Computer based mental illness detection has been a long researched area. Many approaches exist in literature based on different techniques. However, the problem is not completely solved and there remains a lot of scope for further research and development in this field.

After reviewing the relevant literature and research work, some research gaps have been observed:

I. More interdisciplinarity is needed to find better solutions for the screening and management of mental illness.

II. Present technological solutions for screening rely generally on one or two modalities to make predictions about mental health issues. It leads to higher inaccuracy and low acceptability of such solutions. Better and more data and decision-making modalities may be able to overcome these issues.

III. Some innovative, efficient and customized algorithms, datasets and systems need to be developed for multimodal screening and management of health illnesses.

IV. There are not enough platforms for creating awareness in society and changing the mindset of people to accept mental illness like any other disease. Current research is lacking in finding ways and means to help people remove the stigma associated with mental health from their minds.

V. Accessibility to mental health treatment and support is crucial. There is a need to make it better. Technology can play its role in connecting the ones in need (the patients) and those who can provide this support (the qualified practitioners).

VI. From a business standpoint, there is still a significant opportunity to launch new ventures in the specific domain of mental illness.It will make the best of the ideas come out on the ground and make lives better for people struggling with these illnesses.

5. Research Objectives

The proposed study is aimed at determining the root causes of mental health issues in Indian communities, with a particular emphasis for suitability in low resource settings (like rural areas). Prior research suggests that, owing to the lack of awareness and socio-cultural stigma attached to mental disorders, people hesitate to openly discuss the mental health illnesses of themselves and their family members [4]. Particularly, in **rural** areas and low resource settings, people resort to many superstitious practices for the treatment of these disorders rather than seeking the help of qualified clinicians. Deep mental and physical harm is inflicted on the victim as a result of these activities. In view of the wide research gap between existing solutions and the actual needs on the ground, it is proposed to make the approaches and offerings better.

One of the objectives is to put together the collected data, and the expertise of mental health practitioners into a machine learning model for future assessment & classification of new cases. The proposed system will take into account other modalities of computer vision and physiological signal (electroencephalogram-EEG) processing based on emotion analyses. Eventually, the assessment of new algorithms and integration strategies will be researched and evaluated.

The objectives of the proposed research are listed as follows:

1) Study of the perceptions and awareness about mental health in LRS.
2) Study of the factors affecting mental health.
3) Developing ML models for assessment of Depression, Anxiety and Alexithymia.
4) Developing an integrated framework for better mental healthcare in LRS

In a nutshell, the overall objective here is to - "*design and develop a research based, multimodal, low cost, usable and accurate mental health screening & management system that connects all the stakeholders of the problem together in a culturally acceptable way.*"

6. Research Questions

The proposed research will be centered on finding answers to the following questions:

1) What are the perception and awareness of people in low resource settings about mental health?
2) What are the factors that affect the mental health conditions in LRS?
3) How to use ML methods to asses DAA using multiple modalities?
4) What are the most important dimensions of a holistic mental healthcare framework in LRS?

7. Proposed Research Methodology

The proposed research takes an interdisciplinary route for exploration, validation, design and development of new things and concepts. It is at the cross-section of psychology, psychiatry, computer science, traditional mental well-being practices & knowledge, and business management. There is an urgent need for modern research to converge and be more interdisciplinary. It is capable of finding better solutions to a wide range of long-standing issues. Mental illness is such an issue that needs interdisciplinary solutions.

The basic steps in the proposed research methodology are described as follows:

7.1 Interaction with Experts & Mental Healthcare Practitioners:

The first point of contact for this phase will be qualified mental health, illness and wellbeing practitioners (such as psychologists, psychiatrists, hypnotherapists and neuro-linguistic practitioners). A list of such professions will be prepared, keeping in mind the geographical, cultural and social diversity of the regions. Following further deliberation, the shortlisted professions will be contacted.

Various interviews, interactions and brainstorming sessions will be conducted to seek a common consensus about some of the traits and attributes of a person that can help identify the type of illness. What are some interesting facts, characteristics and data about the patients that they encounter in their day-to-day interactions with them? The Delphi technique will be used to seek a common consensus among experts.

In our preliminary exploration and interaction, a group of mental health practitioners sought a common consensus on a set of eighteen vital parameters for estimating the likelihood of whether a person is suffering from depression or not. This set of attributes may be vital for training a machine learning model for automated screening of the mental health of an individual.

7.2 Field Study

After taking the inputs from the mental healthcare professionals, the interaction will be done with people at large, patients and other stakeholders such as grassroot

organizations, healthcare centres, policy framing institutions etc. At the initial stage, some entities/organizations deemed relevant to the work have been identified.

The following types of data will be collected from human subjects (volunteers 18+ years old) for the research work:

1. Responses to Questionnaire (offline and online)

2. Facial Expression Visual Data

3. EEG Data

The primary data is proposed to be collected from the following locations:

1. Village Karauli Bangar, District Gautam Buddh Nagar, UP, India

2. Village Dayanatpur, District Gautam Buddh Nagar, UP, India

3. Village Dharpa Chuharpur, District Bulandshahr, UP, India

4. Village Shyampur, District Dehradun, Uttarakhand, India

5. Village Bidholi, District Dehradun, Uttarakhand, India

6. Raghav Vihar, Prem Nagar, Dehradun, Uttarakhand, India

The secondary data is is proposed to be collected from the following locations:

1. AIIMS Rishikesh, Uttarakhand, India

2. AIIMS Delhi, Uttarakhand, India

Table 1 provides the tentative list of organizations and entities who will be approached for expert consultation and collaborative work. These entities represent grassroot organizations, medical institutions, mental health practitioners and other research institutions working in areas pertinent to the current proposed work.

Table 1: Tentative List of Collaborators for Field Study, Data Collection and Expert Inputs

S.No	Name of Organization / Individual	Entity Type	Remarks
1	Shroff Foundation Trust, Gujarat	NGO	The SFT is providing healthcare services in tribal areas of Gujarat through its three hospitals.
2	Gujarat Digital Academy for Mental Health, Ahmedabad, Gujarat	Government	An extension academy of NIMHANS Bangalore, the biggest mental health and neuroscience research institute in India
3	Foundation for Revitalisation of Local Health Traditions (FLRHT), Bengaluru	NGO	It also runs a research university called Transdisciplinary Research University (TDU) and medical hospital at Bangalore
4	Manas Foundation	NGO	Delhi
5	AASRA	NGO	Mumbai
6	The Banyan	NGO	Chennai
7	Vandrevala Foundation	NGO	Operates a hotline across multiple cities
8	The Live Love Laugh Foundation	NGO	Founded by Deepika Padukone
9	Lifeline Foundation	NGO	Kolkata
10	Mental Health Innovation Network (MHIN)	International Community	A global community of mental health researchers and practitioners working across several countries. ATMIYATA is its initiative for rural India

The required data will be collected through surveys, questionnaires and interviews using online and offline means.

7.3 Design and Development of the System

The basic steps for the approach to the design & development of the system have been depicted in Figure 2. It is evident from the given figure that there are a total of six steps under which the system will be developed.

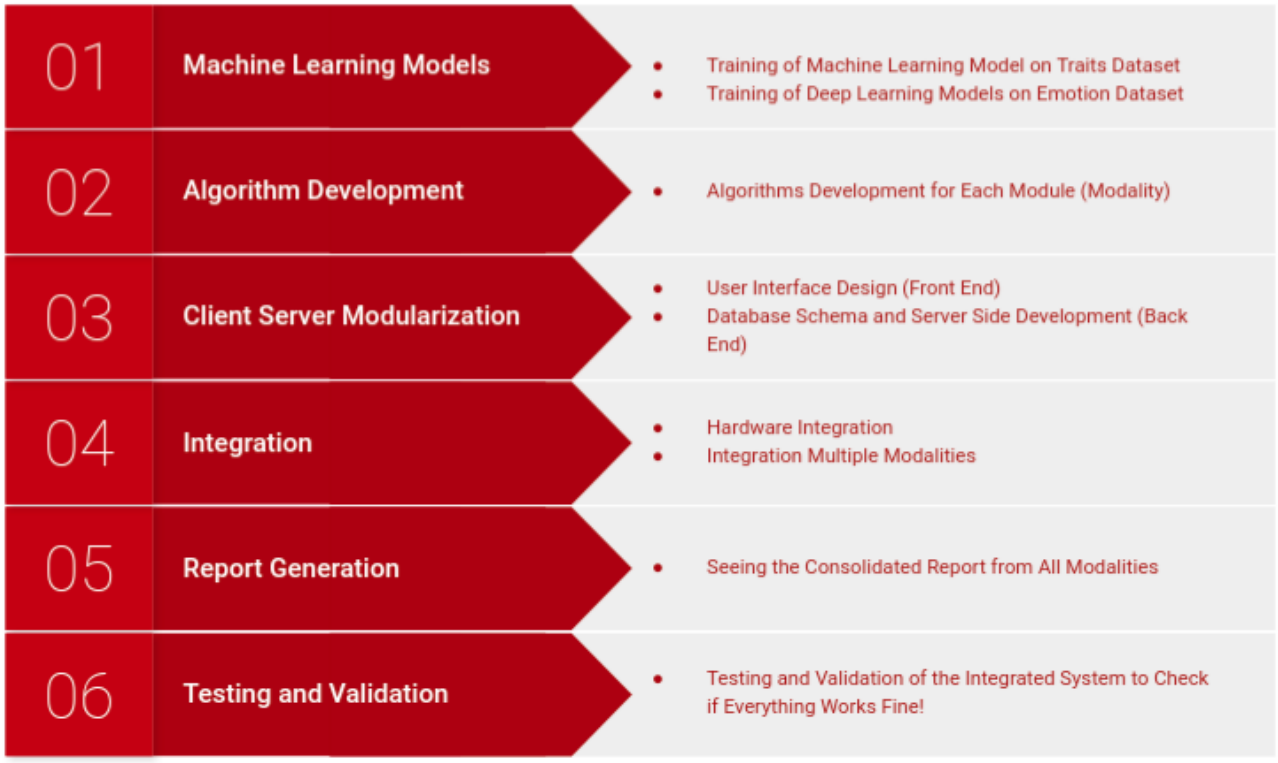

Figure 2: *The Basic Steps in Development of Proposed System*

7.3.1 System Workflow

The proposed system will follow the following workflow for performing various import functions during its execution:

1. User registration
2. After successful registration, users can login with credentials such as user id and password.
3. After login, users have the following flow of actions:
    a. Take self assessment tests for the screening of mental illness
        i. Trait Test (Online/Offline)
        ii. Visual Emotion Analysis (Online/Offline)
        iii. EEG Test (Offline only)
    b. See the consolidated report
    c. Search for mental health support
        i. Read blogs and videos to know about the various types of illnesses

ii. Read about the experiences of others going/gone through similar problems
iii. Get expert help from the professionals, see their ratings and take consultation.

4. Once users enter the details and a live streaming will be completed. A final result will be displayed to the users.

7.3.2 Performance Metrics:

We considered several parameters to evaluate the accuracy of our trained model, such as -

- **Classification Accuracy :** Classification accuracy is used to measure the efficiency and effectiveness of the classification model used in the project. It provides the information in percentages, like, out of the total predictions, how many predictions are correct. So, we can measure the efficiency of a model.
- **False Positive Matrix: The** False Positive Matrix is used to measure how many instances a particular model classifies a negative event as positive. The lower the false positive rate, the better the prediction model.
- **Confusion Matrix:** The Confusion Matrix is a performance metric for machine learning classification problems in which the output can be classified into two or more classes.It is a table with 4 different combinations of predicted and actual values.

7.4 Pilot Study and Exploring Some Business Use Cases

The system will be deployed for use by both end users and practitioners. A user may use it as a self-assessment tool. He may further connect with various support groups and mental healthcare professionals on the platform. During the pilot implementation of the system, user feedback will be collected to further improve the experience. The concept has the potential to scale-up and grow as its popularity increases. Definitely, there will be

some challenges to running the system. With an adequate feedback mechanism, these will be sorted out.

8. Expected Outcomes of the Research

There are many interesting aspects of the proposed research. It will take an interdisciplinary route for exploration and research. It will have the right proportion of technology & ground connection, traditional aspects blended with modernity and establishing universal scientific principles with a fair attention to personal experiences. Some of the prominent outcomes of the proposed research work are listed as follows:

A. **Indegenous Dataset:** The work is proposed to be conducted in formal or informal collaboration with individual mental health practitioners and private & government organizations such as hospitals, colleges and NGOs. With their support, a dataset of mental disease(s) will be created. Subsequently, this dataset will be used as one modality for training machine learning systems for prediction.
B. **AI-enabled Mental Health Portal:** The portal will have the feature of self screening for mental health based on multiple modalities. Further, it will connect the people and practitioners, providing a safe, reliable and accessible platform for mental health support, counseling and treatment. It will also act as a platform for peers to connect and share.
C. **Product Development and Incubation:** After some market and viability analysis, the proposed idea will be launched as a product or service in the market. Considering the need of technology assisted reliable offerings in the mental healthcare and well-being domain, it has potential for growth and sustenance.
D. **Patents and Research Publications:** The extensive research on the proposed topic will yield some good quality research publications and patents.

9. Discussion and Conclusion

Eradicating the mismanagement of mental illness remains a challenge in India. It has been reinforced in the United Nations' Sustainable Development Goals (UN-SDGs) and has been emphasized in key thrust areas of the World Health Organization (WHO). In India, there is a huge gap in availability and demand in the mental healthcare sector, in terms of infrastructure to support mental care, trained professions, and investment. To help millions of people suffering from mental health issues return to a normal life, social awareness must reach out to remote rural communities and low resource settings. The proposed research envisages an interdisciplinary route to overcome some of the challenges of mental healthcare. It tries to fulfill two main objectives. One is to explore the possibility of making research based technical solutions for effective screening & management of mental illnesses. Another goal is to bring together and raise awareness of the various stakeholders in mental healthcare.

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